Exercises Sheet 1

Sunday, May 3, 2020 9:21 PM

Exercise 1

(a) Wavelength of detected light from figure 1 (λ_{obs}) = 1214.2 ± 0.2 Å
$= 1.2142 \times 10^{-7} \pm 2 \times 10^{-11}$ m/s

Wavelength of lyman Alpha line (λ_{rest}) = 1.2157×10^{-7} m/s

hence, $z = \frac{\lambda_{obs}}{\lambda_{rest}} - 1$ = $\boxed{-0.0014 \pm 0.0002}$

(for the rest of the part, I will assume $\sigma_z = 0$)

for radial velocity (v_{obs})

$v_{obs} = cz$
$= 3 \times 10^8 \times -0.0014$
$= \boxed{-420{,}000 \text{ m/s}}$ (moving towards us)

(b) Distance to Andromeda (D) = 780 kpc
Hubble constant (H_0) = 71 km/sec/Mpc

So, radial velocity (v_{exp}) = $H_0 \cdot D$
$= 71 \frac{km}{s \cdot Mpc} \times \frac{780 \text{ Mpc}}{1000}$
$= \boxed{55380 \text{ m/s}}$ (moving away)

No, the expected and measured values are not consistent. The galaxy is moving towards us with much greater magnitude than speed of expanding space.

(c) $z = 0.05$

Radial velocity (v_r) = cz
$= 0.05 \times 3 \times 10^8$ m/s
$= 1.5 \times 10^7$ m/s
(moving away)

distance (D) = $\frac{v_r}{H_0} = 1.5 \times 10^7 \frac{m}{s} \times \frac{1 \text{ s} \cdot \text{Mpc}}{71{,}000 \text{ m}}$

$= \boxed{211.26 \text{ Mpc}}$

Exercise 2

(a) At temperature $< 1.5 \cdot 10^{10}$ k, the reaction will freeze out leading to progressive annihilation of the e^- and e^+. At this point, the Energy is too low for e^-/e^+ production

(b) The ratio between photons and baryons = $10^9 : 1$

Temperature (T) $> 10^9$ k
Energy $> 10^4$ eV

(c) Binding Energy of D = 2.2 MeV = Energy to photodisintegrate Deutron.

Hence, we need photons with Energy $\geq$ 2.2 MeV = 2.2×10^6 eV

Now, we have $E = h\nu$
$\Rightarrow 2.2 \times 10^6 \text{ eV} = 4.135 \times 10^{-15} \frac{\text{eV}}{s} \cdot \nu$

$\Rightarrow \nu = \boxed{5.3 \times 10^{20} \text{ hz}}$

The frequency of photons that disintegrated the Deutron was $\geq 5.3 \times 10^{20}$ hz

Dutrons are present in such small amound because the binding Energy between the proton and neutron was very low $\approx$ 2.2 MeV making it very susceptible to breakup.